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BIG CREEK AQUATIC HABITAT MANAGEMENT and IMPACTS FROM LIVESTOCK GRAZING

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Introduction

Big Creek is located in Rich County, south of Bear Lake near Randolph, Utah. The creek originates on the Cache National Forest and flows northeast 20 miles before entering into the Bear River.

Big Creek drains about a 52 square mile area, and is one of the larger tributaries of the Bear River in Rich County. During a normal water year Big Creek has an annual flow of about 11,370 acre-feet, with a mean annual flow of 15.7 cubic feet per second. The maximum discharge on record is 337 c.f.s. and the minimum discharge is 0.90 c.f.s. as recorded by a U.S. Geological Survey gaging station, located 3.5 miles downstream from Randolph Creek junction, for the 21 year period of record, 1949-70.

The Bureau of Land Management (BLM)administers only a portion of Big Creek, amounting to only 5 streammiles. The remaining land ownership along the stream consists of private holdings of 13 streammiles, and U.S. Forest Service in the upper stream reach of 2 streammiles.

Big Creek is only one of 17 streams in the Randolph Planning Unit consisting of 170,200 acres of national resource land (NRL) administered by the BLM (Figure 1). However, it is the largest stream of the group and the one which was chosen for multiple use development because of its present and potential habitat and fisheries resources and its proximity to public access and recreational use.

The headwaters of Big Creek originate from spring sources near the 8,000 foot (above mean sea level; m.s.l.) elevation in the Cache National Forest while the mouth enters the Bear River at the 6,245 foot (m.s.l.) elevation. The BLM administered portion of the Creek is centered around the 6,596 foot (m.s.l.) elevation level. The water quality is generally good, being a moderately hard, bicarbonate buffered, cold water mountain stream.

The drainage basin consists primarily of a sagebrush, riparian alluvium, rolling hill landform giving way to an aspen-coniferous mountain community in its extreme upper reaches. The watershed consists mainly of a west to east slope of Tertiary Wasatch (Knight) sedimentary formation with some limited exposures of Twin Creek limestone in the headwaters and alluvium and Lake Bonneville deposits in the lower valley near Randolph, Utah.

The BLM administered national resource land on Big Creek is located in the upper reaches some 15 miles above the mouth. The lands primary use is for livestock and sheep grazing and is managed under criteria set up within the Big Creek Allotment Management Plan. This allotment, which Big Creek lies

within, covers 31,540 acres and provides for use of 600 cattle and 450 sheep during the period mid-May through mid-October. This amounts to 3,000 AUM's (animal unit months) for cattle and 2,250 AUM's for sheep.

Fisheries resources consist primarily of rainbow, brown, brook and cutthroat trouts with other non-game species such as, the mottled sculpin, carp, and sucker being present. The majority of these non-game fishes occur in the lower reaches of the creek but have been occurring more frequently in mid-stream reaches as habitat changes occur. The Utah State Division of Wildlife Resources (DWR) stocks Big Creek annually with catchable rainbow trout and cutthroat trout fry. Some cutthroat remain in the stream through natural propagation.

Since the great majority of the grazing use that has occurred on Big Creek occurs within the riparian streambed zone the condition of the habitat (i.e., vegetative cover, streambank soil stability, streambed gravels, and water quality) has been degraded significantly and in many instances eliminated. This deteriorated habitat condition had also led to the reduction in game fish populations within the lower reach of the stream and began to extend into the upper reaches.

As a result of increases in wildlife management personnel within the BLM and desire to become more involved in multiple use management, a habitat management project was developed by the BLM Salt Lake District under whose administrative jurisdiction the Rich County area lies. The project was to provide for habitat management of the contiguous 1.5 mile reach of BLM administered riparian land along Big Creek. The primary objective was to improve the aquatic habitat for the fisheries resources, allowing for the recovery of the riparian vegetation, streambank stability and water quality on NRL. Project work was to include streambank fencing, vegetative bank plantings, bank stabilization structures, and instream improvement structures.

The stream's 1.5 mile reach to be developed was also to serve as a demonstration area to show and document to livestock users the rate of recovery and vegetative potential of riparian areas if managed correctly under multiple use principles. However, the project met with severe resistance from local livestock interest and the project exclosure size was modified to only 1/2 streammile because of this.

Methods

However, in 1970, the BLM did fence off about a 1/2 mile stream area (3300 ft. of stream) and construct 17 instream improvement structures. The structures, placed inside and outside of the exclosure consisted of gabions and trash catcher structures designed to improve pool-riffle habitat in the stream. Access gates were located along the fence to allow visitor entry

for recreational uses. The fence allowed for future grazing uses inside the exclosure, once vegetative productivity was restored, by providing a gateway at the upper and lower end of the exclosure. A large information sign was erected at the downstream end of the exclosure to inform the public of the management intent.

In 1971, an additional 26 instream structures were constructed within the exclosure. During the following years monitoring of the recovery of the habitat and fisheries resources was not accomplished.

In 1973, however, with the addition of a fisheries biologist to the BLM staff, intensive habitat monitoring studies were begun on Big Creek, both inside and outside the exclosure. Habitat studies consisted of physical habitat measurements in the riparian zone as outlined in stream survey procedures presented in BLM Utah State Office Manual Supplement 6671, Release 6-9, dated December, 1975, and in BLM Technical Note #283, dated June 1976. Figure 2 shows the location of the habitat stations. Each habitat station consisted of five transects, each transect spaced 100 feet above the other proceeding upstream. Within the exclosure, a transect was placed each 100 feet for the entire length of the exclosure beginning at the downstream end of the exclosure. These transect studies were designed to inventory and assess stream conditions, including the streambanks vegetative cover and soil stability; stream bottom gravels, pool-riffle areas, and water quality. An example of a typical field data form and reference form is shown in Figures 3 & 4.

Water chemistry measurements were made annually using field test kits as well as obtaining a certified laboratory analyses. Included in the water quality analyses were samples for bacteriological content, ie, total coliform and fecal coliform (colonies per 100 milliliters). Bacteriological analyses were performed by the Utah State Division of Health Laboratory in Salt Lake City.

Sampling of fish populations was accomplished in 1973 by the DWR at the permanently located habitat monitoring sites on the stream (Figure 2). This has been the only fisheries sampling accomplished during the 4-year habitat monitoring period.

Macroinvertebrate sampling was initiated in 1975 under contract to Brigham Young University's (BYU) Center for Health and Environmental Studies and continued in 1976. The 1976 work also included some streambed gravel analysis using a modified McNeil core type sampler (U.S. Forest Service design). These core samples were placed in bags on-site, and taken to the BYU laboratory for analysis. The BLM also conducted some streambed gravel sampling in 1975 and 1976 using the McNeil sampler at selected gravel-riffle areas inside and outside the exclosure. On-site core analysis was done for these samples using the volumetric water displacement method.

Results

Tables 1 through 5 show the results of physical habitat measurements from 1973 to 1976 for the various habitat parameters. Although five habitat stations are present on Big Creek, only Stations 1 to 3 will be discussed in detail because of their environmental homogenity and close proximity to each other in relation to concentrated livestock use in the study area. Stations 4 and 5 were inventoried only in 1973 during the initial stream survey, and exhibit additional stream factors, such as beaver ponds and headwater reaches which do not lend readily to direct comparisons to lower stations but do show the diversity of habitat types and stream condition at increased elevation levels.

Channel Width

Mean channel widths in the grazed portions (Stations 1 & 3) increased by 1.4 feet and 0.7 feet respectively in four years giving both channel areas a mean width in excess of 27 feet. Whereas mean channel widths inside the exclosure (Station 2) decreased by 2.5 feet. Several areas, however, outside the exclosure have lost up to 3 feet of stream bank annually because of trampling from livestock. Station 2 did exhibit a mean 1 foot channel loss in 1974. This is attributable to trespass livestock being allowed within the exclosure for six weeks due to the fences being cut by vandals. This loss however, was gained back in 1975 and continued in 1976 to a mean channel width of 16 feet.

The stream's thalweg at the site of one gabion instream structure outside the exclosure is now ten feet removed from a once stabilized streambank. The right bank of the gabion structure is now the left bank of the water's edge.

Similarly, mean water widths have increased and water depths decreased with widening of channel banks. Station 1 increased water width by a mean of 1 foot in four years, while mean depths decreased by 0.22 feet. Class 1 & 2 pools within Station #1 have decreased in quality and use for fisheries to Class 4 & 5 pools lacking depth and cover requirements. These pools which were 4-5 feet deep in 1973 are now no more than 1.5 feet deep due to channel changes and silt depositions attributed to livestock use and trampling.

Station 2, inside the exclosure decreased water widths as channel banks stabilized by a mean of 1.1 feet in four years. Mean depths also decreased within the channel by a mean of 0.26 feet in four years, from a mean of 1.1 feet to 0.8 feet deep. This factor has not significantly reduced fisheries habitat since deep pools of Class 1 rating in 1973 remain the

same class in 1976 with no loss in depths. While some stream areas in mid-channel have a small depth loss, additional depth and cover area has been obtained from stabilized undercut banks.

Sediment and Spawning Gravels

Spawning gravels were rated according to their frequency along transect lines and consisted of fine gravels (0.1-1.0 inches) and coarse gravels (1-3 inches). Their occurrence at Stations 1,2, & 3 decreased yearly by 48%, 21% and 35% respectively (Table 1). Station 2, within the exclosure decreased the least amount dropping from 42% occurrence in 1973 to 33% in 1976. Unstable channel conditions outside the exclosure are contributing heavy silt deposition to the streambed, either covering spawning gravels or washing them downstream.

While the streambottom contains a heavy silt load the substrate is very porous and loose, subject to shifting during spring and flood flows. The decrease in spawning gravels is related to an increase in sediments over the 4-year period. Sediments were classified as percent occurrence along each transect and some bottom core samples were taken in 1976-76 by BLM/BYU. Sediment occurrence on streambottom materials increased annually by 46%, 16%, and 166% on Stations 1,2, & 3 respectively. Station 2 increased the least, even though the 3300 foot exclosure reach acted as a silt settling basin because of reduced gradient and instream structures. The structures, however, all were functioning properly, both upstream and downstream pools, and sediments chiefly occurred in downstream pool eddies and point bars at stream meander bends.

Streambed core samples taken by BLM in 1975-76, and BYU in 1976 show similar results on stations sites sampled, although one was analyzed in the field and the other in the lab. (Table 6 & 7). The percent of fine materials less than 0.84 mm range from 23.1% to 26.5% below the exclosure, while inside exclosure the range was from 22.4% to 28.5%. BLM's sample at the upstream end of the exclosure (26.9%) compared favorably to BYU's sample just upstream. Past studies (Bjornn, 1969) relating to survival and emergence of steelhead trout and chinook salmon show survival varies with amounts of fine materials in gravels. The percent of materials passing the 6.35 mm sieve (caught by 0.84 mm sieve) showed that chinook salmon fry experienced difficulty in emerging from 20 to 40% fines and few emerged from 40% fines (sand). Only 50% of steelhead fry emerged from gravels with 50% sand, and only 10% emerged from gravels with 55% sand. Egg mortalities of 60-80% for chinook salmon, and 40-60% for steelhead trout occur when gravel interstices fill with 30-40% sands (6.35 mm).

Sediment samples (BLM) on Big Creek in all areas reflect fine materials less than 6.35 mm greater than 48% and materials less than 0.84 mm greater than 25%. Based on these figures, in relation to salmon-steelhead studies, it can be theorized that smaller salmonid species (ie, Big Creek species) would have high egg mortality in Big Creek from natural spawning efforts due to high sand-silt deposition on the streambed.

Pool-Riffle Quality

The percent of pools within the stream channel reaches decreased in Stations 1 & 2 in 4 years by 18% and 4% respectively, but increased in Station 3 (above exclosure) by 94%. Percent of pools occurring within the reaches of Stations 1, 2, & 3 presently make up 59%, 77% and 66% of the reaches respectively. The increase in pools above the exclosure (Station 3) is the result of shifting and cutting channels, but while additional pools are present their pool quality rated only 37% or a decrease by 39% in 4 years from a 61% quality rating due to increases in channel widths and decreases in depths.

Station 1 (below exclosure) decreased in pool quality by 26% over the four year period but pool-riffle ratios increased to 82% of optimum (if 50:50 ratio considered optimum). However, the dominance of pools on this site is not favorable since their quality for fisheries use is minimal due to lack of size and depth requirements.

Station 2 (inside exclosure) increased in pool quality by 8% over 4 years due to hydrologic actions of instream structures and presently have a quality rating of 42%. Most pools remain as Class 1 pools based on size and depth (73 feet) requirements despite heavy silt loads passing through the reach. Pool-riffle rations increased 15%,from 40% to 46% of optimum in 4 years. As the instream structures settled and stabilized, permanent pools were dug out and riffles formed on the downstream end. Additional riffle areas have been formed above instream structures as gradient changes have occurred from structure settling.

Streambank Cover & Stability

Stations 1 & 3 both exhibited similar cover and stability ratings due to livestock use of the riparian zone. Native willows and grasses have been heavily utilized and in most cases eliminated from streambank zones.

Based on cover/stability rating criteria (Figure 4) both stations exhibited lowest possible ratings of 25% or bare-sparsely grass covered banks affording no streamside shade-pool cover. Station 3 was poorly vegetated in 1973 (29%) but since then what little vegetation remained has been removed and it presently has exposed streambanks (25% rating). While Station 1 stability ratings remained at 43% throughout the 4 years (less than 50% stable), Station 3 increased slightly from 45% to 53% stability. This is due to lower bank heights, and while devoid of woody vegetation, have rounded off vertical cut banks and begun stabilizing somewhat. Since this area of Station 3 is only about 500 feet in length and located between the upper exclosure fence and a BLM boundary fence its use by livestock is not as intense as below the exclosure.

Station 2 has increased in cover since the 1970 exclosure fence was constructed and increased from a low 25% (bare) to a 40% rating (grass, bursh covered-medium height) in a 4 year period ending in 1973. Similarly, stability increased from about 43% (similar to Stations 1 & 3) in 1970 to 84% in 1973 going from mostly unstable to greater than 50% stable. In 1974 vandals cut the exclosure fence in several spots and trespass cattle used the area for 6 weeks before their removal and fence rewiring by BLM. As a result of this intense grazing use, after 4 years rest, cover ratings dropped by 35% and stability by 14%. Native willow stock propagation and plantings by Boy Scout Troops were eliminated or browsed back to basal stem area. Willow stems from resprouting and decadent plants that had grown to 48 inch maximum height in 4 years and just starting to exhibit vigorous growth were reduced to basal stems. Streambanks which had become grassed over and begun to stabilize were re-fractured and began sluffing into the creek from livestock trampling. In several instances 3 feet of streambank were lost due to excessive trampling. Trampling also caused end-cutting around six instream structures which required maintenance to arrest erosive streambank conditions.

In the two years following fence cutting, cover and stability have increased by 35% and 14% respectively to ratings of 35% cover quality and 82% stable quality in 1976, almost reaching habitat levels in 1974 prior to trespass livestock use. Willow shoots have resprouted and stems reached a maximum height of 24 inches in 1976. Additional native willow stem plantings cut in the field and planted by Boy Scouts in the spring of 1976 have experienced about 40% survival in 2 years. Six month survival value for the 500 willow stems planted in vertical and horizontal stem cut patterns in 1975 was 90%, but decreased in 1976 due to bank scouring from high discharges and trampling from increased fisherman use within the exclosure.

Clippings of vegetative grass species in plots, (6 square feet) determined from color infrared photos in 1975 showed areas outside the exclosure adjacent to the stream to support only 4 to 22 pounds per acre biomass in July after 2 months use by livestock. Inside the exclosure, in "wet meadow" grasses adjacent to the stream 6,300 pounds per acres biomass was produced, and adjacent "dry meadow" grasses showed 1,800 pounds per acre biomass produced following 2 years recovery from some grazing use.

In 1976 a rating system (Figure 4) was developed to rate the percent use of ungulate animals (primarily livestock) on stream bank vegetative and soil communities. These ratings (Table 1) seem to correlate well to ratings for bank cover and bank stability. High cover and stability

ratings within exclosure areas reflect habitat that is 90-100% impact free from grazing use, while areas outside the exclosure with no cover and unstable soil banks reflect excessive grazing use with 90-100% environmental damage.

Desirable Streambottom Materials - Benthic Productivity

Streambottom materials rated desirable from a productivity level of benthic organisms for fish food are rubbles, gravels, silts, muck, and organic debris (leaves, sticks, etc). Excessive silt depositions were not counted in this determination but only those fine silt layers covering bottom materials.

All three stations have exhibited an increase in these materials in the 4 year monitoring period increasing by 21%, 5%, 11% for Stations 1,2, and 3 respectively. Present ratings indicate a 99%, 79%, and 94% desirability rating for occurrence of these materials at Stations 1,2, and 3. These increases are attributable to increases in fine settled sediments as well as exposure of gravel materials below and above the exclosure from the streams gradient cutting actions.

These increases in desirable materials for benthic organism production are not truly representative of a healthful status of the stream. As a result of benthic macroinvertebrate sampling work done for the BLM (1975-76) by BYU results showed in 1975 that the creek was dominated by dipterans (mostly Chironomidae), averaging 81% and 51% of the samples in June and August respectively (Figure 8). The low community diversity at all sites in June samples reflect this chironomid dominance. There appeared no difference in macroinvertebrate distributional patterns between sites outside and within the exclosure, either by numbers or biomass. In the August sample, diversity values ($\bar{d}$) had increased at all sites, reflecting the simultaneous decrease in dipteran (chironomid) dominance and increase in numbers of ephemeropterans (mayflies). Baetis spp. accounted for about 95 percent of the mayfly dominance. Samples in 1976 showed similar comparisons with chironomid dominance being 50% in August and 24% in October samples. Diversity values were higher than in 1975; but very similar between sampling dates and sites. Higher values reflect increases in numbers of ephemeropterans (mayflies) and trichopterans (caddisflies). Baetis spp. and Ephemerella spps. accounted for mayfly dominance, and Hydropsyche spp. and Brachycentrus americanus accounted for caddisfly dominance (Figure 9).

In both years there were very few plecopterans (stoneflies) in the system except the more tolerant toward pollution forms, such as Pteronarcella sp. and Isoperla sp.

Water Quality

The water quality in Big Creek is good as shown in Tables 10 and 11. It is a moderately hard, bicarbonate buffered cold water mountain stream. Nutrient levels are adequate to ensure good algal productivity. Nitrate and phosphate levels remained at a fairly high level throughout the summer, probably due to cattle grazing in the bottomlands. In natural streams the nutrients are high during spring runoff and then decrease throughout the summer. Other measured water quality standards appear to be within the Utah criteria for Class CC waters (waters suited for coldwater fisheries).

Total and fecal coliform counts were at relatively low levels both years considering the number of cattle grazing in the area; however, on June 19, 1975 and August 24, 1976 bacterial levels were relatively high. This could have resulted from rains and resultant runoff during the preceding two or three days. They were still below Utah standards for Class CC waters, but higher than other mountain stream waters with no intense livestock grazing concentrations.

Water temperature values are shown in Tables 12 & 13. In 1975 mean minimum and maximum temperatures were 8.0 ^{o}C and 15.5 ^{o}C respectively (for a 75-day period) with a maximum temperature of 19.5^{o}C on July 13. In 1976 mean minimum and maximum temperatures were 9.2 ^{o}C and 17.3 ^{o}C respectively (for a 61 day period), with a maximum of 21.5 ^{o}C on July 10. Unlike 1975 when temperatures greater than 18 ^{o}C decreased after August 6, similar temperatures above 18 ^{o}C continued on until sometime after August 10 (instrument malfunctioned on this date and no further data obtained).

These temperatures reflect conditions of the stream within the middle of the exclosure in pool areas. Recording thermographs were not available for temperature monitoring below the exclosure, however, pocket thermometer readings taken during field trips indicated maximum temperatures were only 2-3 ^{o}C higher in the Station 1 reach below the exclosure during the same time periods. These higher temperatures reflect the widened and shallow stream channel reaches devoid of vegetative cover.

Habitat Optimum Values

Values for optimum habitat ratings were based on summaries of pool-riffle ratios, pool quality, desirable streambottom materials, and streambank cover and stability ratings (Duff & Cooper, 1976).

Stations 1 & 2 have increased total habitat values slightly by only 13% and 2% respectively since 1973, currently being 59% and 57% percent of habitat optimum. Station 3 has decreased 3.5% being currently 55% of optimum. While these values are intended to reflect overall quality

of a stream's habitat environment they tend to be somewhat misleading. Station 2, inside the exclosure, which has shown habitat recovery has a lower rating by 2% than Station 1 which is subject to heavy livestock use. This can be accounted for by the high value ratings on Station 1 for pool-riffle ratio and desirable streambottom materials. Though high, these ratings do not reflect quality habitat since depth, cover, and stability ratings are low resulting in less desirable fish habitat as shown by low fish numbers. These summary ratings then must be looked at along with individual habitat characteristics results in order to ascertain the true habitat condition of the stream reaches under investigation. Possibly, as additional annual sample data is collected a more meaningful picture of habitat optimum rating values will surface.

Fish Populations

Sampling of fish populations at habitat monitoring sites was only accomplished in 1973. Table 14 shows the summary of three sampling efforts at Stations 1,2, and 4. Station 2, inside the exclosure, had 3.6 times more fish than outside the exclosure. Numbers of fish per mile in grazed vs. ungrazed portion of Big Creek (based on a 528 foot electrofishing station) were 130 fish per mile for Station 1 as compared to 470 fish per mile in Station 2. Similar comparisons were noted for biomass in pounds per acre of fish produced, from 7.22 lbs/acre in Station 1 to 26.22 lbs/acre in Station 2.

Station 4 reflected higher figures in some categories than the lower 2 stations but not as much as one would expect in a beaver pond-stream environment. Station 4 had 5.2 times more fish than Station 1 and 1.5 times more fish than Station 2. Numbers of fish per mile were 680 or 1.5 times greater than Station 2. However, biomass was only 26.63 lbs/acre, only 0.4 lbs/acre greater than Station 2. This station is located about 3 miles upstream, above the exclosure in a grazed channel portion the creek exhibiting a stream-pond situation with numerous beaver ponds. This area marks the lowest downstream habitat area acceptable to beaver. Large willows are common in this area and most have withstood impacts from livestock better than downstream areas where heavy concentrations of livestock occurs. However, loss of low vegetative bank cover and trampling has caused bank instability in this reach also, which probably is the reason why significant increases in fish populations were not noted in this reach as compared to Station 2. Future fish sampling stations are needed in this area below the beaver dams, yet above the Station 2 exclosure to adequately portray fish conditions in grazed areas within this channel reach.

Conclusions

Data gathered during the habitat monitoring period following exclosure construction has shown that riparian habitat can respond favorably from intense livestock use through rest. Degraded riparian soil and vegetative streambank components recovered substantially in the 4-year period (1970-74) following fencing while similar areas outside the exclosure continued to decline.

Streambank stability had started to show stabilization and vegetative cover vigor and growth was beginning to show increased growth potential after 4 years. However, trespass livestock use in 1974 reduced these habitat components to near pre-fencing ratings (4 years past) for vegetative cover, and 2 year improvement ratings for stability. Streambanks were re-fractured along "old" fracture lines and channel width increased by a mean of 1-foot from loss of bank soil in 1974, after showing positive response after 4-years rest.

Following two-years rest (1974-76) from this trespass grazing,soil and cover ratings again approached initial 4-year rest condition habitat ratings. It appears from these initial evaluations that for livestock grazing to occur within the exclosure it would have to be limited in numbers for a short term seasonal use following seed ripening beginning, pending future observations, in 2 years hence or four years following trespass use.

Data on habitat recovery within the exclosure has shown the possibility exists for limited grazing use along the Big Creek ecosystem within a minimum of 6-8 years after rest. This is predicated on the assumption that the habitat is in similar condition to that existing habitat found below and above the Big Creek exclosure. Since similar habitat values are present on other streams in Rich County managed by BLM it is possible to assume similar rest periods must be given to these degraded riparian habitats before recovery will allow limited grazing use without further substantial habitat loss or decline.

Initial (and only) fisheries sampling has shown the preferences of fish to habitat conditions. Some 3.6 times more fish were shown to be inside the exclosure, where habitat has significantly recovered, then compared to continued degraded condition stream reaches above and below the exclosure. Additional fisheries sampling would have been extremely

beneficial in years following initial sampling (1973) in order to ascertain correlations between the degree of habitat recovery and fish population, composition and biomass response. Hopefully, future sampling can be undertaken in cooperation with the Utah Division of Wildlife Resources to determine fisheries values in these reaches.

All reaches sampled showed an increase in sediments covering streambottom gravel materials. This included the improved stream reach inside the exclosure. Continued livestock grazing above the exclosure is the primary cause of this sedimentation because of streambank instability and erosion from trampling use. The upper stream reaches do not contain enough manageable BLM land, in which to control grazing impacts and as a result this private land grazing use is continuing to contribute sediments to downstream reaches. Although sediment is prevalent within the exclosure (Station 2) and the instream improvement structures are operating somewhat as silt retention basins, all are functioning properly. Some sediment and silt covers upstream pool basins above the instream structures but a slight gradient is present to maintain adequate flushing conditions through each structure. Pools below the structures continue to be Class 1 quality pools (3' deep). Sediment deposition has, and continues to occur in pools with side eddies below the instream structures and in point bars at channel meanders and bends. It is a probability that instream structures will continue to function adequately within the exclosure although continued sediment movement is present within the reach. It is not anticipated that the streambottom will not cleanse itself unless complete restoration (rest) of the upper watershed riparian reaches is accomplished. This is not possible because of private ownership patterns and grazing uses in these upper reaches.

These studies have shown that the operationable ability of instream structures to function properly on stream reaches with heavy grazing use is poor. Although design and placement may be engineeringly adequate, the continued use of livestock on streambanks can accelerate bank instability and erosion leading to end-cutting and wash-out of instream structures. Of six structures placed outside the exclosure in 1970-71 only 2 remain operational six years later. And these two are in poor condition and subject to wash-out from bank trampling impacts from livestock use. Although instream structures can aid in streambank soil stabilization their operational usefulness should be considered in view of present and future grazing uses as well as benefit-cost ratios for installation, annual maintenance and site life span. Continued grazing uses along stream reaches under habitat management implementation would negate any beneficial uses and effects anticipated from instream structure placement.

Although habitat recovery has been shown to occur within the exclosure areas (Station 2), as compared to reaches outside the exclosure, full habitat recovery has not been achieved. This is due to upstream impacts on the stream environment from uncontrolled grazing uses. Sediments and high nutrient loads continue to impact flora and fauna within the exclosure and degrade physical, chemical, and biological water quality values as shown by indicator elements and species. Because of these uncontrollable parameters in the upper watershed it is impossible to evaluate adequately habitat and fish recovery as well as advance proper grazing rates (AUM's) and length of use. Continued monitoring of these Big Creek habitat stations is planned to be continued for future years, but a more intensive study is needed within a controlled watershed(s) where the various management and habitat improvement alternatives and degrees of grazing system use can be studied and evaluated in detail. Such studies are needed now by responsible state-federal agencies to encompass total watershed management concepts for multiple-use management of all physical and biological resource components of the watershed.

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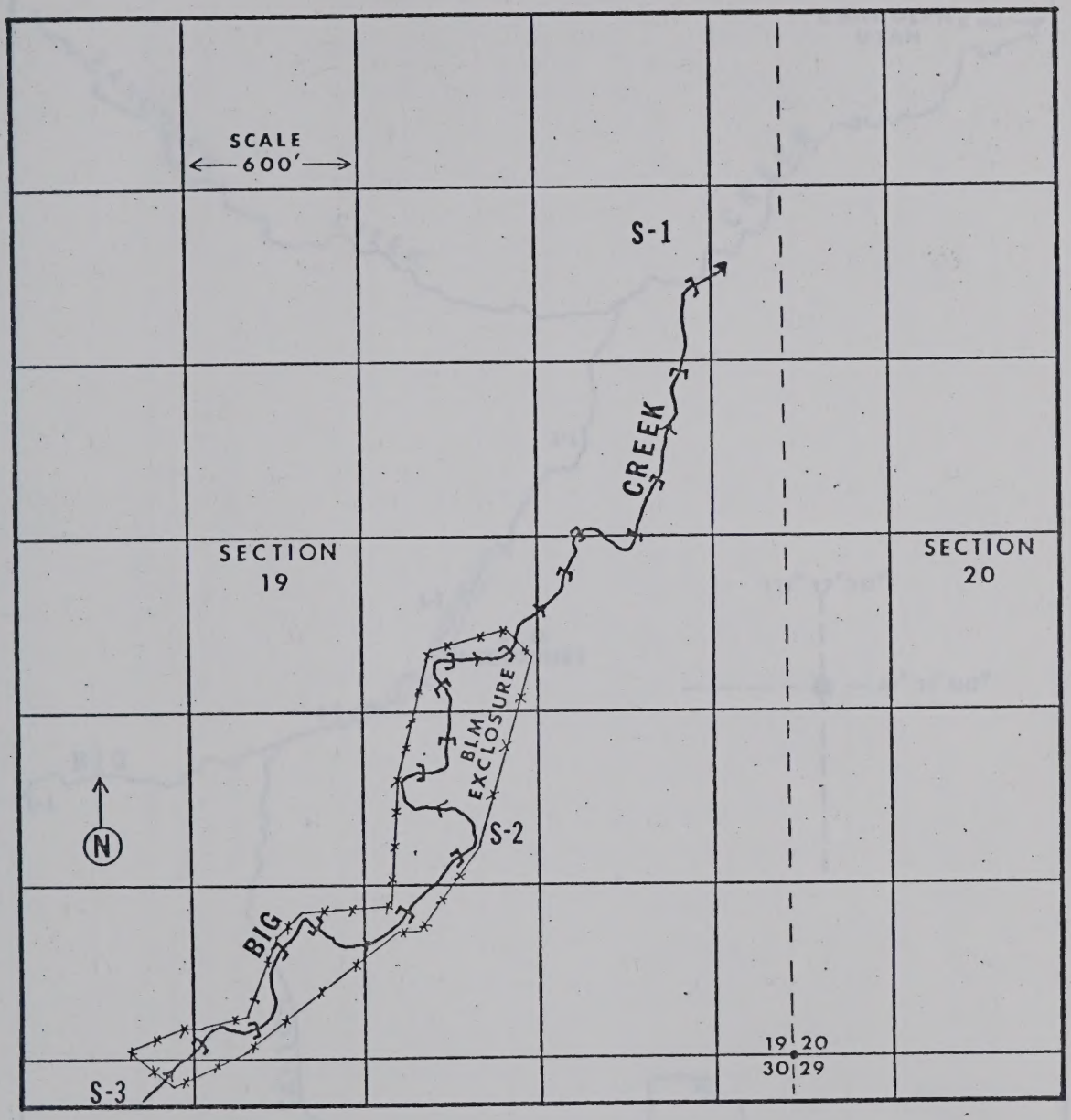


Figure 2. Big Creek habitat improvement exclosure showing fisheries improvement structures (5).

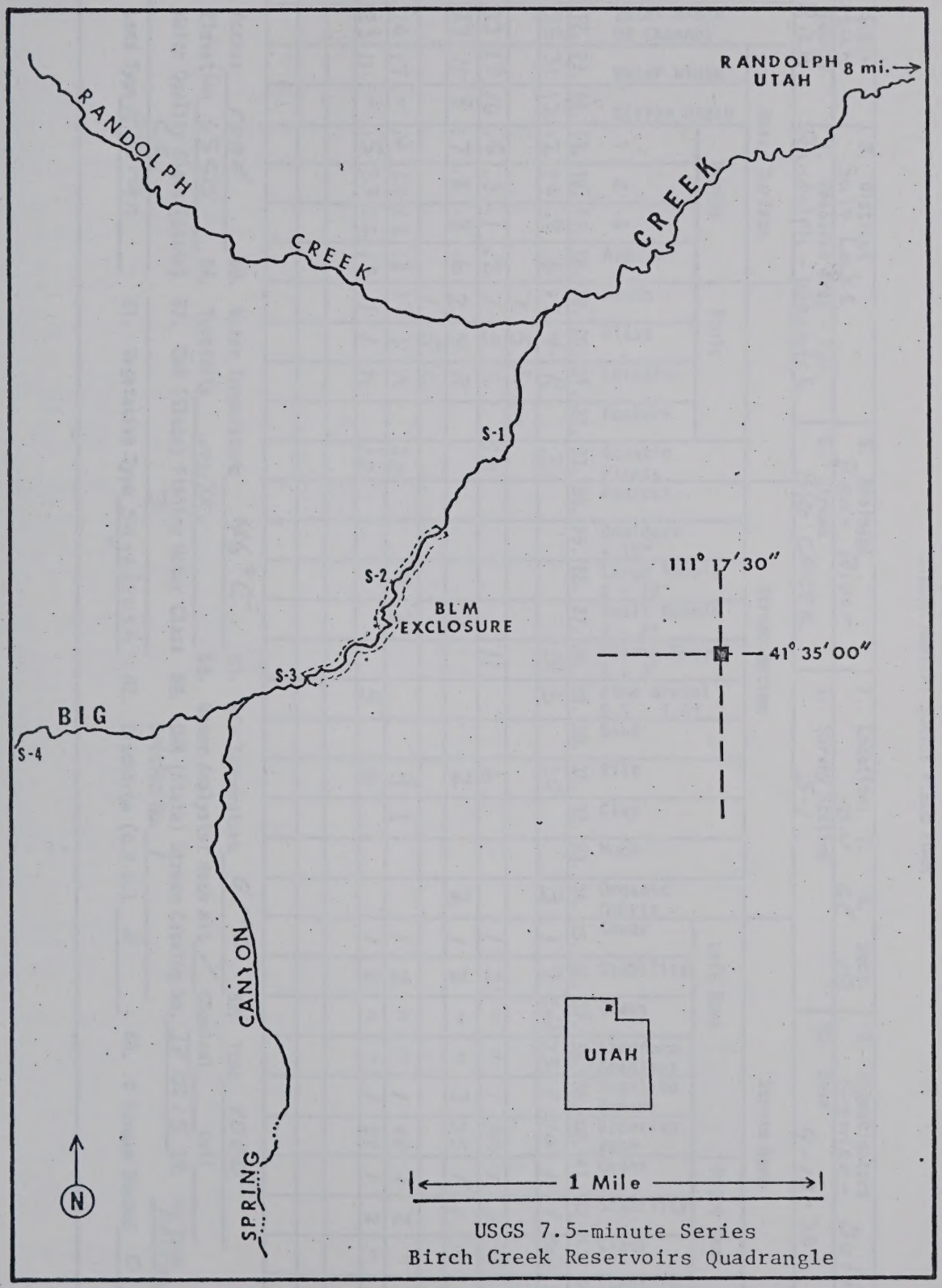


Figure 1. Big Creek study area.

Figure 3. Typical Big Creek Stream Habitat Survey Field Form.

USO 6671-1
(June 1975)

STREAM HABITAT SURVEY FIELD FORM

1. State	3. District	5. Drainage	7. Location: T. R. Sect.	9. Investigators
Utah	Salt Lake	Bear River	10N 6E 19	Gomer - Duff
2. County	**4. Resource Area - P.U.**	**6. Stream**	**8. Survey Station**	**10. Date**
Rich	Randolph - Wasatch	BIG CREEK	S-1	9-10-76

		Water Surface						Stream Bottom														Stream Bank															
				Depths				Pools														Left Bank							Right Bank									
Transect Number	Total Width Of Channel	Water Width	Riffle Width	1	2	3	Avg.	Width	Class	Location	Feature	Aquatic Plants	Bedrock	Boulders + 12"	Large Rubble 6 - 12"	Small Rubble 3 - 6"	Coarse Gravel 1 - 3"	Fine Gravel 0.1 - 1.0"	Sand	Silt	Clay	Muck	Organic Debris	Cover	Stability	Class	Landform Gradient	Ungulate Damage	Riparian Zone	Cover	Stability	Class	Landform Gradient	Ungulate Damage	Riparian Zone	Stream Gradient	Velocity
11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.	31.	32.	33.	34.	35.	36.	37.	38.	39.	40.	41.	42.	43.	44.	45.	46.	47.	48.
1	35	31	12	.2	1.4	.9	.6	12	4	R		3R					5	3		20			3	1	2	Soil	25	1	20	1	1	Soil	5	1	150	.1	2
								7	5	L																											
2	33	17	16	.5	.3	.1	.2	1	5	L		1R					11			6				1	2	"	"	1	100	1	1	"	"	1	100		
3	27	11	8	.7	.8	.8	.6	2	4	R						7				2			2	1	2	"	"	3	25	1	1	"	"	1	50	1	2
								1	5	L																											
4	20	17	-	.4	1.6	1.2	.8	17	1	A		2R			4	3				9	1			1	2	"	"	1	10	1	2	"	"	1	200		
5	23	11	-	.5	2.3	2.6	1.3	11	1	A		1R						5		6				1	2	"	"	1	20	1	2	"	"	1	50	1	.5

49. Access road 50. Water Temperature 46°C 51. Air Temperature 61°C 52. Time 1000

53. Elevation 6550 54. Turbidity milky 55. Water Analysis: Hach Kit ✓ Chemical ____ Coli ____

56. Water Quality Class (State) 2c 57. DWR (State) Fishing Water Class 3 58. DWR (State) Stream Catalog No. IP Q.15 Section No. 1 59. MU Zone Recreation

60. Land Type Riparian 61. Vegetative Type Sagebrush 62. Discharge (c.f.s.) 8 63. % Stream Shaded 0

Figure 4. BLM Stream Habitat Survey Reference Form.

USO 6671-4
June, 1975

6671 - STREAM SURVEYS
Exhibit 4
STREAM HABITAT SURVEYS REFERENCE FORM

Appendix 4
(.23A)

MEASUREMENT OF STREAM WIDTH AND DEPTH

1. Measure stream width to nearest foot. When a transect bisects separated channels, list each channel separately from left to right looking downstream, in alphabetical order, i.e., T1a, T1b, etc.

2. Measure depth at 1/4, 1/2, and 3/4 width to nearest inch. Sum of measurements ÷ 4 = avg. depth.

BANK COVER MEASUREMENTS (50 feet above and below transect)

4 - Medium to heavy cover of trees and/or tall shrubs
3 - Scattered trees and/or dense tall shrubs
2 - Medium to heavy cover of tall grass, forbs and/or low shrubs
1 - Scattered low grass, forbs and/or small shrubs or exposed bank.

(Vegetation must be within 1/2 its height of water's edge to qualify as streambank cover.)

BANK STABILITY

4 - Bank totally stable
3 - >50% stable
2 - <50% stable
1 - Totally unstable

BANK COVER - Dominant composition of streambank components 50 feet above and below the end of transect. Composition classes can be boulder, gravel bar, exposed soil, grass and rocks, grass and soil, soil and rocks, rooted soil (trees and brush), etc.

POOL FREQUENCY AND LOCATION

Each intersected pool width is measured to nearest foot. Designate location by symbol L (left), R (right), and C (center) in reference to left-hand bank facing downstream.

POOL CLASS RATINGS

Size (Measurements refer to the longest axis of the intersected pool.)
3 - Pool larger or wider than average width of stream.
2 - Pool as wide or long as average stream width.
1 - Pool much shorter and narrower than average stream width.

Depth Ratings	Total Ratings	Pool Class
3 - over 3 feet	8-9	1
2 - 2-3 feet	7	2
1 - under 2 feet	*5-6	3
	4-5	4
	3	5

UNGULATE DAMAGE
4 - Bank stable; 90-100% impact free.
3 - < 50% damage; 50-90% impact free.
2 - > 50% damage; 50-90% damage.
1 - Excessive; 90-100% damage.

Cover Ratings
3 - Abundant cover
2 - Partial cover
1 - Exposed

*Sum of 5 must include 2 for depth and 2 for cover.

CLASSIFICATION OF BOTTOM MATERIAL

Fine Gravel	0.1 - 1.0 inches
Coarse Gravel	1 - 3 inches
Small Rubble	3 - 6 inches
Large Rubble	6 - 12 inches

(See field form for others)

(measure total intercepted bottom materials to nearest foot. Aspect, not individual materials, should govern classification.)

MEASUREMENT OF WATER TURBIDITY

Clear)
Milky) Account for source
Muddy)

FISHERMAN ACCESS

Remote - No trail
Low-standard trail - Game or nonmaintained trail
Improved trail - Maintained
Low-standard roads - Without drainage
Improved roads - With drainage

AQUATIC VEGETATION
R - rooted - (record to nearest foot of intercepted vegetation)
C - clinging

TICKLER LIST FOR REMARKS
1. Dams and barriers
2. Pollution information
3. Channel changes (manmade)
4. Erosion potential
5. Fish (number--size--species)
6. Creel information and fishing pressure
7. Number fish planting access sites
8. Spring sources
9. Water diversions
10. Beaver activity
11. Spawning gravel availability
12. Camera point information
13. Channel debris
14. Loss of streamflow

BLM MANUAL SUPPLEMENT
State Office-Utah

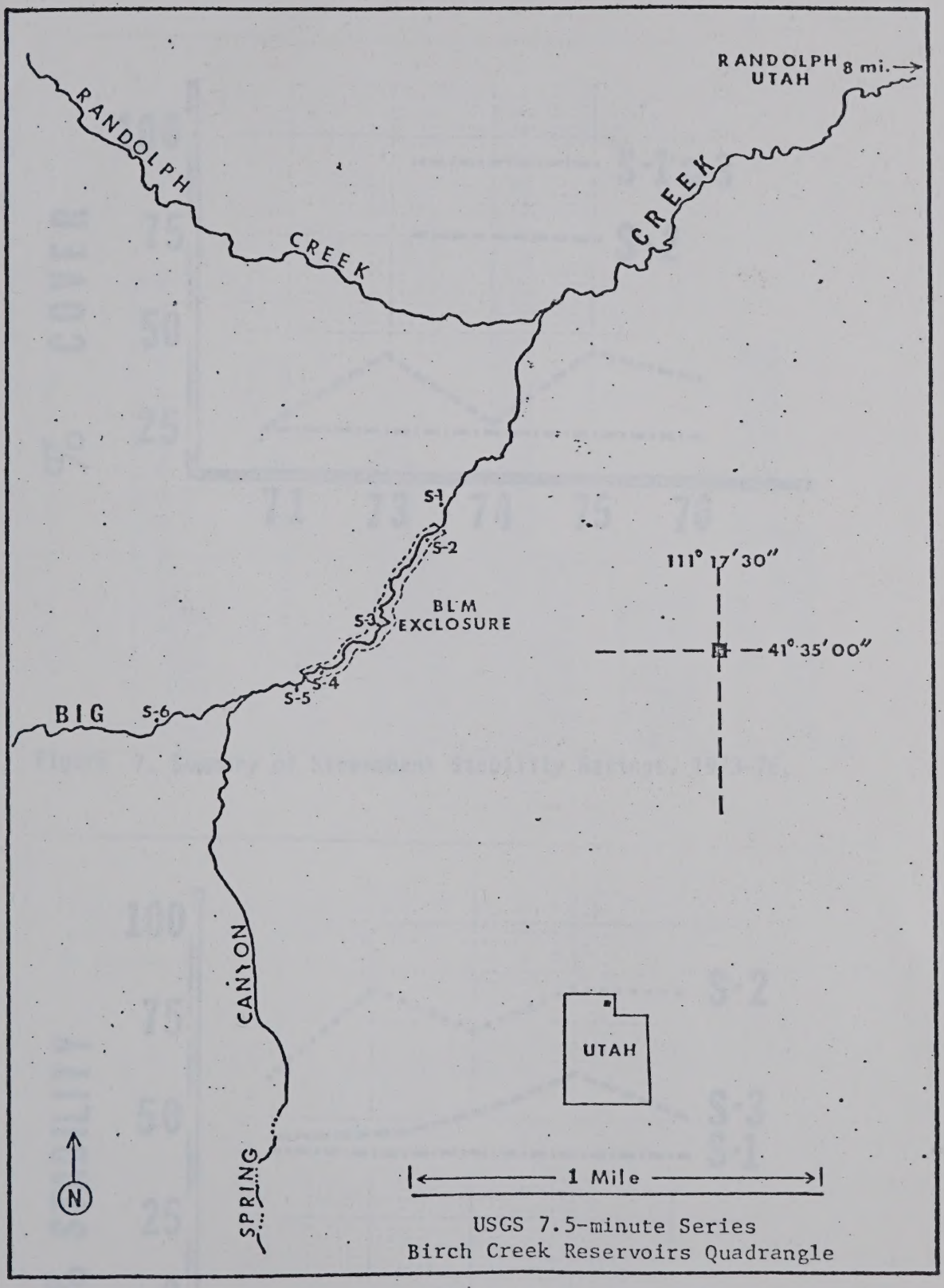


Figure 5. Big Creek study area, BYU Habitat Sites, 1975-76.

Figure 6. Summary of Vegetative Bank Cover Rating, 1973-76.

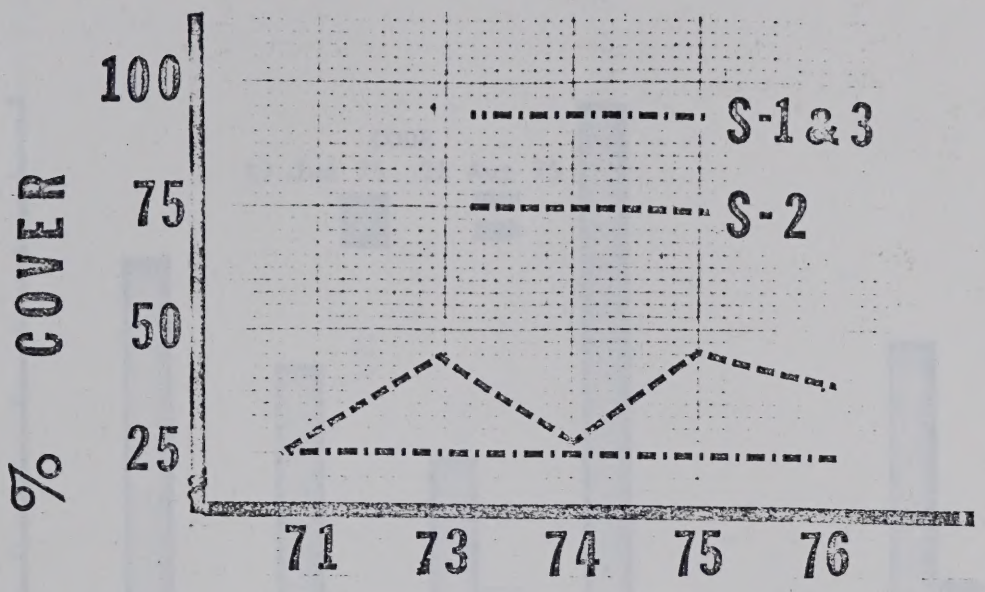
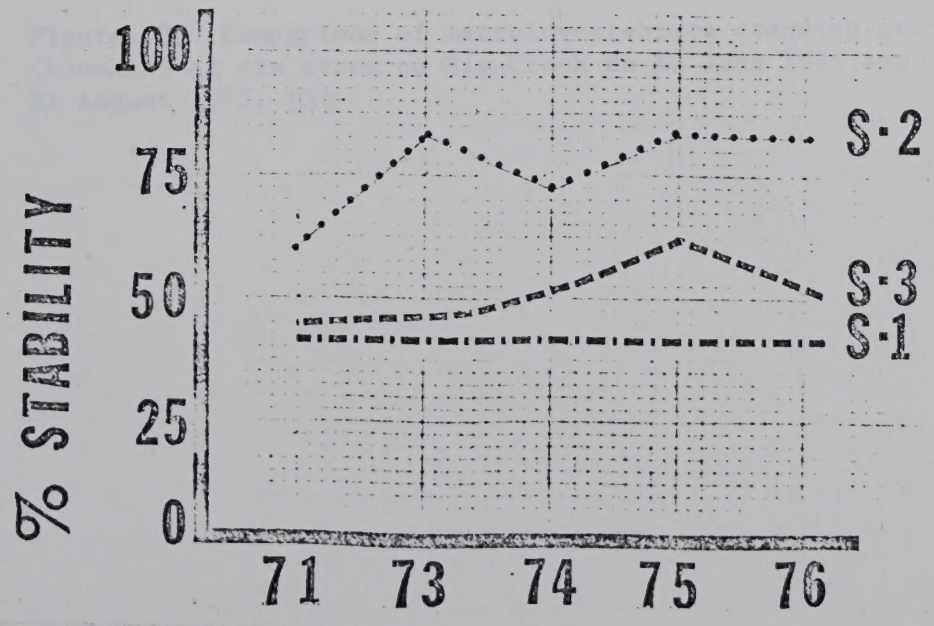
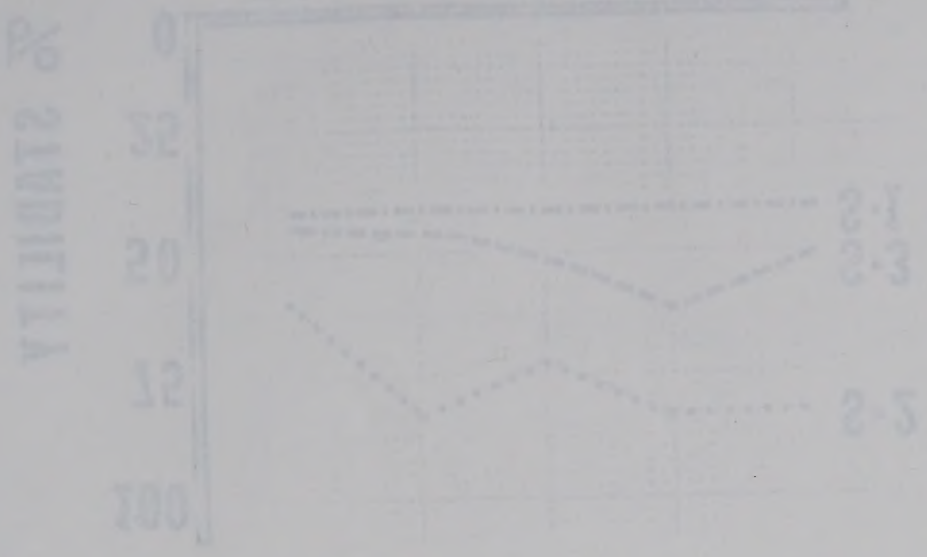


Figure 7. Summary of Streambank Stability Ratings, 1973-76.




%
ATTENUATS
0
32
20
12
100
1-5
2-3
2-5

%
REVOS
32
20
12
100
2-5
1-5

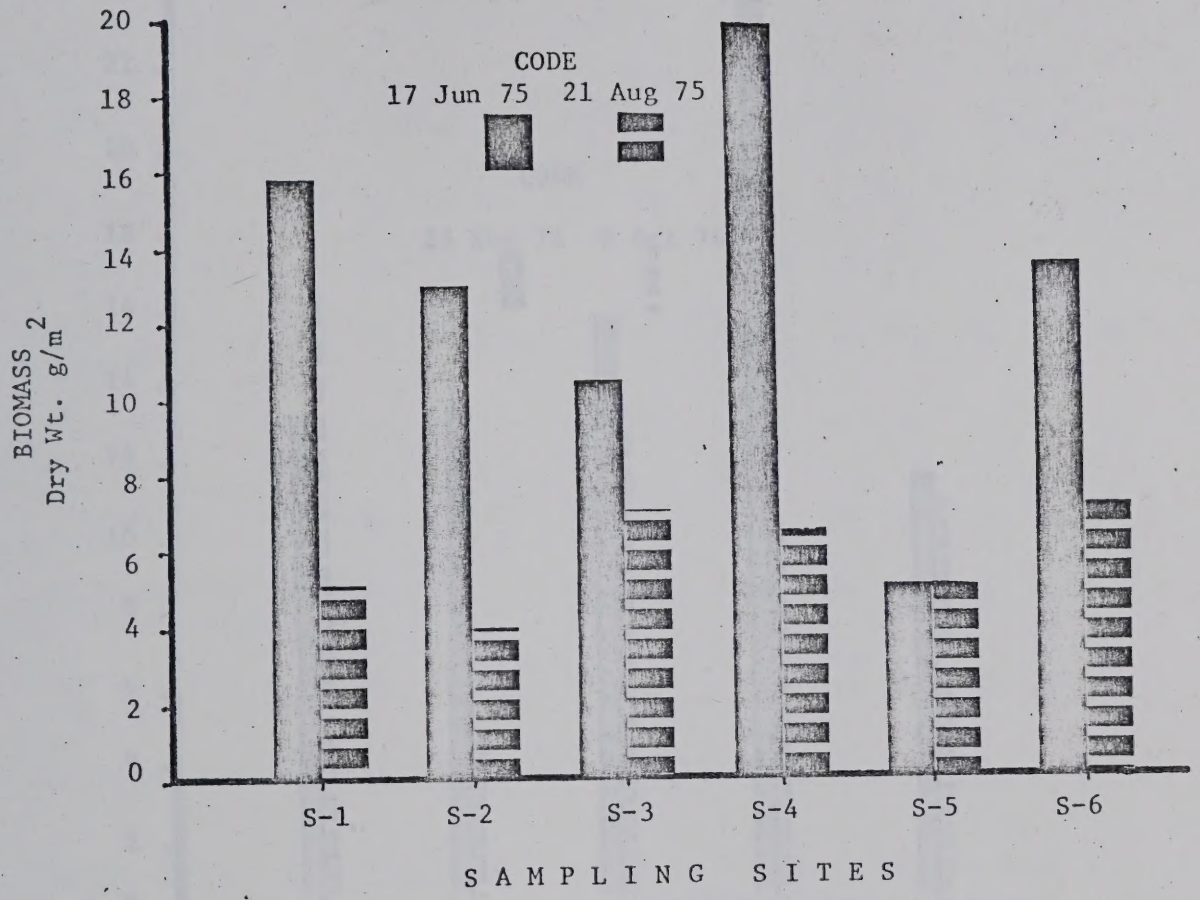


Figure 8. Comparison of macroinvertebrate standing crop (biomass) at six sites on Big Creek on 17 June 1975 and 21 August 1975. BYU

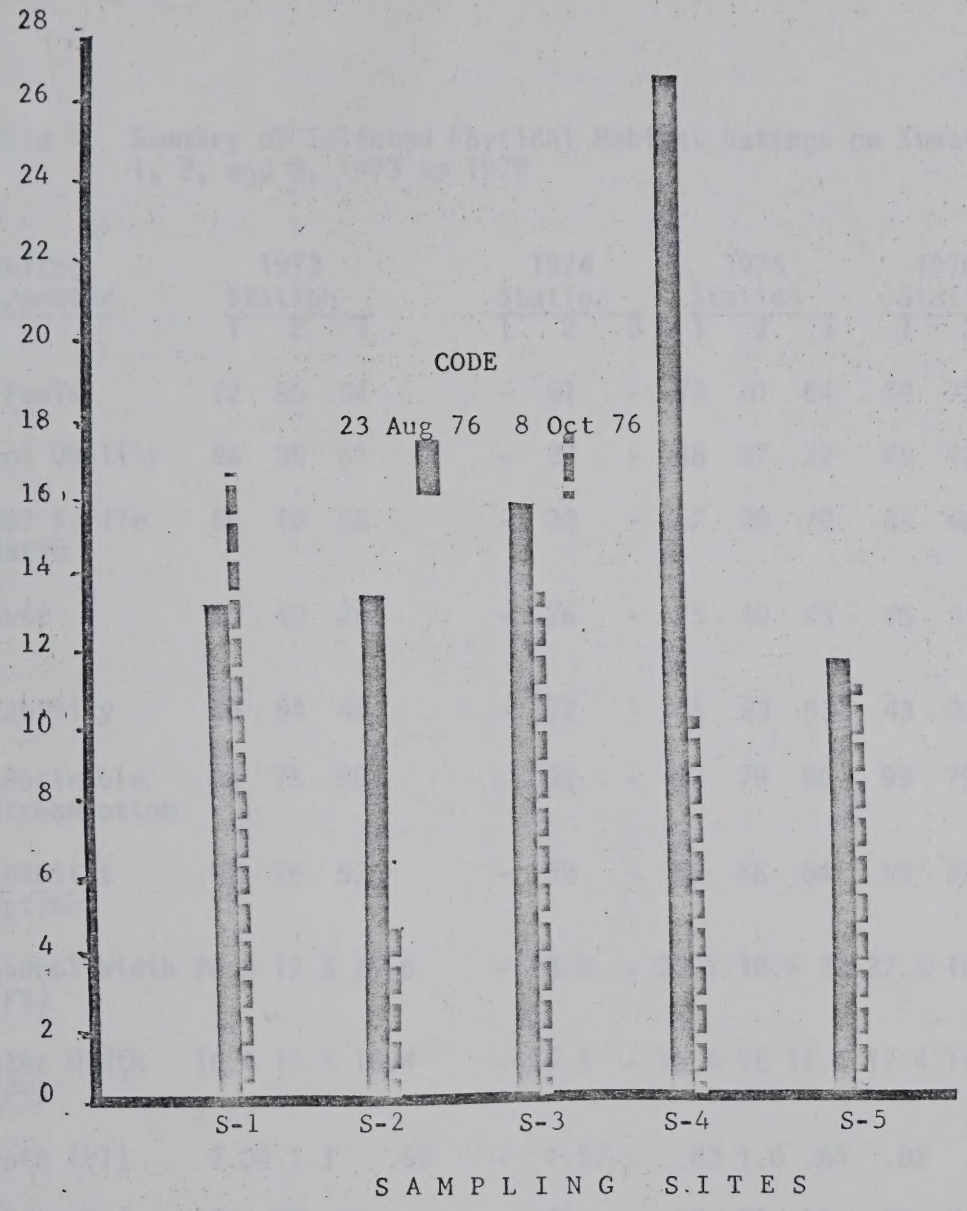


Figure 9. Comparison of macroinvertebrate standing crop (biomass) at five sites on Big Creek on 23 August and 8 October 1976. BYU.

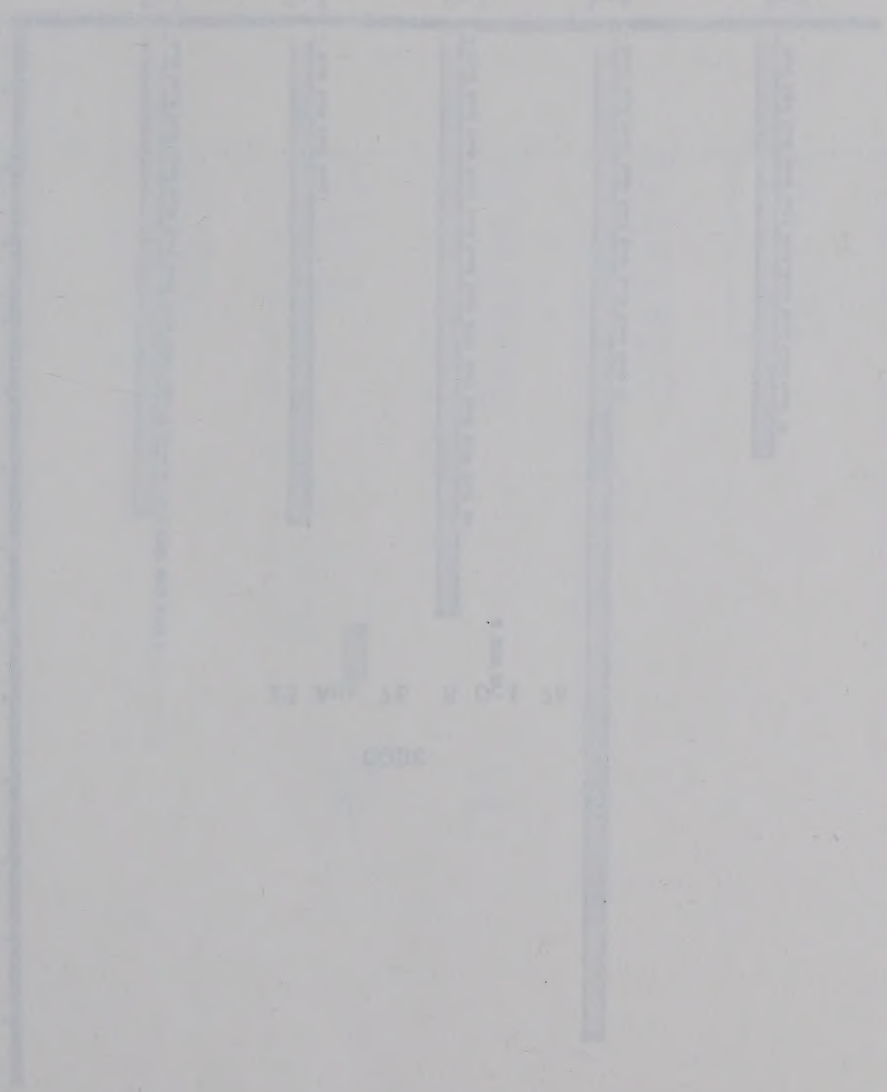


Table 1. Summary of Selected Physical Habitat Ratings on Stations 1, 2, and 3, 1973 to 1976

Habitat Parameter	1973 Station			1974 Station			1975 Station			1976 Station		
	1	2	3	1	2	3	1	2	3	1	2	3
% Pools	72	80	34	-	81	-	74	81	64	59	77	66
Pool Quality	56	39	61	-	37	-	48	37	72	45	42	37
Pool Riffle Ratio	56	40	68	-	38	-	52	38	72	82	46	68
Cover	25	40	28	-	26	-	25	40	25	25	35	25
Stability	43	84	45	-	72	-	45	83	63	43	82	53
% Desirable Streambottom	82	75	85	-	92	-	93	79	86	99	79	94
% Habitat Optimum	52	56	57	-	53	-	52	56	64	59	57	55
Channel Width (FT)	26.2	17.5	26.6	-	18.5	-	27.1	16.5	27	27.6	16	27.3
Water Width (FT)	16.4	15.5	16.4	-	15.1	-	16.4	15	14.4	17.4	14.4	12.4
Depth (FT)	1.04	1.1	.52	-	1.57	-	.83	1.0	.64	.82	.84	.62
% Spawning Gravels	54	42	82	-	46	-	32	31	56	28	33	53
% Sediment	35	45	15	-	39	-	44	50	40	51	52	40
Ungulate Damage Rating	-	-	-	-	-	-	-	-	-	30	83	25

Table 2 Habitat Summary for Big Creek Station #1

Habitat Parameter	1973	1974	1975	1976
% Pools	71.9		74.3	58.6
Pool-Riffle Ratio	56		52	82
Pool Quality	56		47.7	45
% Desirable Stream-bottom	81.7		92.6	98.8
Bank Cover	25		25	25
Bank Stability	42.5		45	42.5
% Habitat Optimum	52.24		52.46	58.6
Channel Width	26.2		27.1	27.6
Water Width	16.4		16.4	17.4
Depth	1.04		0.83	0.82
% Spawn Gravels	53.6		31.7	27.5
% Sediment	35.3		43.9	50.5
% Water within channel	62.6		60.5	63
Ungulate Damage	____	____	____	30
Survey Date	July 26		Aug. 7	Sept. 10

Table 3 Habitat Summary for Big Creek Station #2

Habitat Parameter	1973	1974	1975	1976
% Pools	79.5	80.7	80.6	76.8
Pool-Riffle	40	38	38	46
Pool Quality	39	37.4	36.9	42.2
% Desirable Stream-bottom	75.1	91.9	79.2	79.2
Bank Cover	40	25.7	40.2	34.5
Bank Stability	84	71.9	83	82.2
% Habitat Optimum	55.6	52.98	55.46	56.8
Channel Width	17.5	18.5	16.5	16.0
Water Width	15.5	15.1	15.0	14.4
Depth	1.1	1.57	1.0	0.84
% Spawn Gravels	41.6	45.98	30.5	33.1
% Sediment	44.5	39.1	50.3	51.8
% Water Within channel	88.6	81.3	90.8	89.9
Ungulate Damage	____	____	____	82.9
Survey Date	July 26	July 29	Aug. 6	Sept. 9

Table 4 Habitat Summary for Big Creek Station #3

Habitat Parameter	1973	1974	1975	1976
% Pools	34.1		63.9	66.1
Pool-Riffle	68		72	68
Pool Quality	61		72	36.5
% Desirable Stream-bottom	85.4		86.1	93.5
Bank Cover	28		25	25
Bank Stability	45		62.5	52.5
% Habitat Optimum	57.5		63.5	55.1
Channel Width	26.6		27	27.2
Water Width	16.4		14.4	12.4
Depth	0.52		0.64	0.62
% Spawn Gravels	81.7		55.5	53.2
% Sediment	14.6		40.3	40.3
% Water within channel	61.6		53.3	45.6
Ungulate Damage	____	____	____	25
Survey Date	July 26		Aug. 21	Sept. 9

Table 5 Habitat Summary for Big Creek Station #4/5

Habitat Parameter	S-4 1973 Beaver Pond Area	S-5 1973 USFS Kitty Cabin
% Pools	86.2	94.3
Pool-Riffle	28	12
Pool Quality	26.5	10.3
% Desirable Stream-bottom	67.9	60.4
Bank Cover	37.5	80
Bank Stability	65	92.5
% Habitat Optimum	44.9	51
Channel Width	29	13.2
Water Width	21.8	10.6
Depth	0.96	0.6
% Spawn Gravels	32.1	17
% Sediment	59.6	71.7
% Water within channel	75.1	80.3

Table 6 . Mean Percent Composition by Weight of Stream Substrates from Big Creek, Rich County, Utah, 1976. Samples taken from gravel beds in stream riffles from three general areas - (1) below stream exclosure; (2) within stream exclosure; and (3) above exclosure. Samples were taken on two dates during 1976 - (1) 23 August and (2) 8 October. BYU.

Sediment Size (diameter) (ASTM Designation D-422)	Below Exclosure		Within Exclosure*		Above Exclosure	
	23 Aug 76 4 samples	8 Oct 76 4 samples	23 Aug 76 8 samples	8 Oct 76 4 samples	23 Aug 76 4 samples	8 Oct 76 4 samples
Gravel: 3 inch to 4.76 mm	71.6	60.5	61.8	56.5	66.0	54.6
Coarse Sand: 4.75 - 2.00 mm	8.4	10.0	8.8	8.2	7.2	10.4
Medium Sand: 1.99 - 0.42 mm	13.2	16.3	13.2	20.1	14.4	20.1
Fine Sand: 0.41 - 0.074 mm	6.5	12.9	15.7	14.5	12.1	14.5
Silt and Clay: <0.073 mm	0.3	0.3	0.5	0.7	0.3	0.4
Mean Percent Fines, <0.085 mm	14.0	23.1	24.0	28.5	20.6	27.3
Range of Percent Fines	12-18	9-34	16-34	20-53	17-26	11-64

Discharge: 23 Aug. 1976 = 7.6 to 8.1 c.f.s.
8 Oct. 1976 = 12.9 to 13.8 c.f.s.

Table 7. Summary of BLM Sediment Sampling, 1975-76

1975 Date/Station	% Fines Passing Sieve 6.35 mm	0.84 mm	Samples
August 7 (11 c.f.s.)			
1. S-1, T-2 (below exclosure)	42.9	34.2	5
2. At Fence, outside below exclosure	51.9	22.8	5
3. Inside exclosure (mid)	46.9	26.4	5
4. Inside exclosure (upper)	56.6	32.8	5
	mean 49.6	mean 29.1	
1976			
July 9 (8 c.f.s.)			
1. S.1, T-2 (below exclosure)	48.4	25.3	2
2. At Fence, outside below exclosure	54.3	32.8	2
3. Inside exclosure (mid)	-	-	-
4. Inside exclosure (upper)	42.6	20.2	2
	mean 48.4	mean 26.1	
September 10 (8.39 c.f.s.)			
1. S.1, T-2 (below exclosure)	52.8	26.5	5
2. At Fence, outside below exclosure	47.1	24.3	5
3. Inside exclosure (mid)	51.5	22.4	5
4. Inside exclosure (upper)	44.0	26.9	5
	mean 48.9	mean 25.0	

Table 8. Summary of 1976 Macroinvertebrate Sampling Data, BYU

Sampling Site	No. of Fauna	Total - Number/m^2 x	- Dry Weight x g/m^2	- d	No. Samples	Standard Deviation	Percent SE of Means	Coeff. of Variation
S-1								
23 August 76	25	58,162	13.1	2.960	5	2390	19.8	44.2
8 Oct. 76	25	21,996	16.5	3.398	4	336	8.2	16.4
S-2								
23 August 76	24	48,983	13.4	3.006	5	1867	17.9	40.1
8 Oct. 76	21	21,262	4.4	2.961	4	1032	26.1	52.2
S-3								
23 August 76	26	39,640	15.8	2.985	5	--	19.0	42.5
8 Oct. 76	22	21,821	13.5	3.344	4	784	19.3	38.6
S-4								
23 August 76	29	88,589	26.3	2.453	5	2923	15.9	35.5
8 Octo. 76	22	14,340	10.1	3.444	4	349	13.1	26.2
S-5								
23 August 76	23	42,773	11.9	2.228	5	1671	18.8	42.0
8 Oct. 76	23	35,605	10.9	3.177	4	598	9.0	18.1

Table 8. Summary of 1976 Macroinvertebrate Sampling Data, EPD

Sampling Site										
S-1										
23 August 76	25	24,173	13.1	2,560	5	2190	75.8	44.2		
8 Oct. 76	25	21,256	10.5	3,456	4	236	8.2	10.4		
S-2										
23 August 76	24	25,264	13.9	3,002	5	1667	17.3	40.1		
8 Oct. 76	21	21,264	9.4	2,501	4	1032	26.1	52.2		
S-3										
23 August 76	20	29,640	15.8	2,992	5	--	76.0	42.5		
8 Oct. 76	22	21,861	13.5	3,241	4	784	13.3	38.6		
S-4										
23 August 76	25	26,565	26.3	2,453	5	2923	15.9	32.5		
8 Oct. 76	22	14,240	10.1	3,464	4	349	13.1	26.2		
S-5										
23 August 76	24	26,273	11.6	2,229	5	1671	72.6	42.0		
8 Oct. 76	24	16,005	10.8	3,171	4	598	3.0	18.1		

Table 9. Summary of 1975 Macroinvertebrate Sampling Data, BYU

Sampling Site	No. of Taxa	Total $\bar{X}$ Number/m^2	$\bar{X}$ Dry Weight g/m^2	$\bar{d}$	No. Samples	Standard Deviation	Percent SE of Means	Coeff. of Variation
S-1								
17 June 1975	26	48,850	15.9	1.52	4	-	-	-
21 August 1975	27	39,683	5.1	2.95	4	-	-	-
S-2								
17 June 1975	30	54,521	13.0	1.98	4	142.8	2.2	3.1
21 August 1975	28	44,708	4.0	2.57	4	1977.1	36.8	52.0
S-3								
17 June 1975	27	38,628	10.5	0.81	4	250.5	3.0	5.3
21 August 1975	29	41,405	6.9	2.43	4	1466.8	20.9	36.2
S-4								
17 June 1975	31	40,415	19.9	1.17	4	504.6	5.1	10.1
21 August 1975	31	28,406	6.6	2.99	4	1213.6	14.6	29.2
S-5								
17 June 1975	28	21,412	5.1	1.01	4	469.4	4.2	9.3
21 August 1975	28	25,189	5.0	2.67	4	-	-	-
S-6								
17 June 1975	30	46,548	13.5	1.84	4	-	-	-
21 August 1975	29	50,830	7.0	2.69	4	-	-	-

Table 8. Summary of 1975 Macroinvertebrate Sampling Data, BYU

Sampling Site									
S-1									
17 June 1975	20	16,850	12.9	1.52	4	-	-	-	-
21 August 1975	27	31,809	5.1	2.95	4	-	-	-	-
S-2									
17 June 1975	30	64,321	12.0	3.38	4	1652.0	5.2	3.3	
21 August 1975	30	46,200	4.0	2.51	4	1972.1	38.8	53.0	
S-3									
17 June 1975	27	90,000	10.6	0.81	4	2801.0	3.0	3.3	
21 August 1975	29	61,400	6.9	2.43	4	1660.0	20.8	36.2	
S-4									
17 June 1975	27	60,674	13.9	1.17	4	506.0	8.1	10.3	
21 August 1975	30	36,000	6.6	2.39	4	1213.6	14.6	25.2	
S-5									
17 June 1975	25	21,914	8.1	1.01	4	459.4	4.2	9.3	
21 August 1975	26	25,169	6.0	2.07	4	-	-	-	-
S-6									
17 June 1975	30	15,964	13.5	1.34	4	-	-	-	-
21 August 1975	29	20,250	7.0	2.59	4	-	-	-	-

Table 10. Big Creek Water Quality Analysis, 1975, BYU.

Analysis* by	Test	17 June 1975			21 August 1975		
		S-1	S-3	S-5	S-1	S-3	S-6
	Time	0900	1220	1540	0830	1100	1330
1	Alkalinity, total as $CaCO_3$, mg/l	206	202	200	218	208	196
1	Bicarbonate as HCO_3, mg/l	208	226	224	251	239	233
1	Boron as B, mg/l	--	--	--	--	--	--
1	Calcium as Ca, mg/l	82	58	60	63	58	55
1	Carbonate as CO_3, mg/l	14	10	10	7	7	3
1	Chloride as Cl, mg/l	7	7	8	7	6	4
1, 3	Conductivity, µmhos/cm (25° C)	367	367	380	285	320	310
1	Hardness as $CaCO_3$, mg/l	292	238	195	230	221	208
1	Hydroxide as OH, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
1	Magnesium as Mg, mg/l	21	22	11	17	18	17
3	pH	8.2	8.2	8.2	8.1	8.1	8.1
1	Potassium as K, mg/l	0.7	0.6	0.6	0.7	0.7	0.7
1	Sodium as Na, mg/l	6.3	5.8	5.8	5	5	4.8
1	Sulfate as SO_4, mg/l	8	7	7	6	6	5
1	Total Dissolved Solids	225	232	225	--	--	--
3	Turbidity, JTU's	1	1	1	10	5	5
3	Dissolved Oxygen as O_2, mg/l	9	9	9	9	9	9
1	Nitrate as N, mg/l	0.33	0.27	0.32	0.24	0.33	0.29
1	Phosphate (Total) as P, mg/l	0.025	0.021	0.004	0.013	0.026	0.017
1	Phosphate (ortho) as P, mg/l	0.025	0.021	<0.001	0.013	0.026	0.017
3	Air Temperature, °C	8	14	20	16	25	22
3	Water Temperature, °C	7	10	14	9	12	15
5, 1	Total Coliform, MPN/100 ml	930	930	930	43	75	23
5, 1	Fecal Coliform, MPN/100 ml	930	930	430	23	23	23

*1. BYU Environmental Analysis Laboratories
2. USGS
3. Field determinations
4. Bionics
5. Utah Department of Health and Welfare

Table 11. Water Quality Analysis, Big Creek. Performed by BYU Environmental Analysis Laboratory. 1976.

	Above Exclosure 24 Aug 76	Below Exclosure 24 Aug 76	Below Exclosure 8 Oct 76
Alk, (tot) as $CaCO_3$	196 mg/l	206 mg/l	200 mg/l
Bicarbonate as HCO_3	221 mg/l	238 mg/l	236 mg/l
Calcium as Ca	56 mg/l	61 mg/l	54 mg/l
Carbonate as CO_3	9 mg/l	6 mg/l	4 mg/l
Chloride as Cl	7 mg/l	7 mg/l	11 mg/l
Conductivity (25° C)	398 umhos/cm	422 umhos/cm	405 umhos/cm
Fluoride as F	--	--	--
Hardness as $CaCO_3$	216 mg/l	224 mg/l	212 mg/l
Hydroxide as OH	<.1 mg/l	<.1 mg/l	<.1 mg/l
Magnesium as Mg	18 mg/l	17 mg/l	18 mg/l
pH	8.62	8.50	8.42
Potassium as K	.8 mg/l	.8 mg/l	.7 mg/l
Sodium as Na	4.6 mg/l	4.8 mg/l	4.7 mg/l
Sulfate as SO_4	7 mg/l	7 mg/l	6 mg/l
Total Diss. Solids	214 mg/l @ 180°C	221 mg/l @ 180°C	205 mg/l @ 180°C
Turbidity	2.8 FTU	4.0 FTU	1.6 FTU
Nitrate as N	.17 mg/l	.23 mg/l	.20 mg/l
Phosph.-ortho as P	.009 mg/l	.014 mg/l	.018 mg/l
MPN Coliform total	250 /100 ml	1500 /100 ml	240 /100 ml
MPN Fecal Coliform	240 /100 ml	1100 /100 ml	23 /100 ml
Boron as B		70 ug/l	19 ug/l

Table 12. Big Creek water temperature data--daily minimum and maximum temperatures (°C) for June 18 to July 25, 1975.

Date	Min	Max	Date	Min	Max
June 18	--	9.5	July 7	10.5	19.0
19	5.0	8.5	8	10.5	20.0
20	3.0	9.0	9	11.0	18.0
21	6.0	12.0	10	10.5	19.0
22	5.5	18.5	11	10.5	16.0
23	6.5	14.0	12	10.0	14.0
24	6.5	15.0	13	9.5	19.5
25	8.0	11.5	14	10.5	18.5
26	4.5	15.0	15	11.0	19.0
27	5.5	15.5	16	10.5	14.0
28	6.5	16.0	17	8.5	16.0
29	6.5	17.0	18	10.0	19.0
30	6.5	17.0	19	10.0	19.0
July 1	7.0	17.5	20	10.5	17.0
2	8.5	18.5	21	9.5	18.5
3	10.0	12.5	22	10.5	19.0
4	9.0	19.5	23	10.0	18.0
5	10.5	18.0	24	9.5	18.0
6	9.5	19.0	25	10.0	18.5
15-day mean		11.8	15-day mean		14.0

Table 12. Big Creek water temperature data--daily minimum and maximum temperatures (°C) for August 6 to September 11, 1975.

Date	Min	Max	Date	Min	Max
Aug. 6	10.0	18.5	Aug. 25	5.0	14.0
7	10.5	16.5	26	6.0	15.5
8	7.5	16.5	27	8.5	13.5
9	7.5	17.0	28	7.0	14.5
10	9.5	17.0	29	6.5	14.5
11	9.5	15.5	30	6.0	15.0
12	9.5	14.5	31	7.5	15.0
13	9.0	13.0	Sep. 1	7.0	13.5
14	8.5	14.0	2	5.5	14.0
15	9.0	16.0	3	5.0	14.0
16	7.5	15.5	4	6.0	14.0
17	8.5	16.0	5	5.5	14.5
18	8.5	16.0	6	6.0	14.5
19	7.0	14.0	7	5.0	14.0
20	8.0	12.0	8	6.0	14.5
21	7.5	15.5	9	6.0	13.5
22	8.5	15.0	10	10.0	11.0
23	8.0	14.5	11	8.0	11.5
24	7.5	14.0			
15-day mean		11.6	15-day mean		10.3

Table 13. Big Creek Water Temperature Data -- Daily minimum and maximum temperatures (°C) for May 28 to Aug. 13, 1976

Date	Max.	Min
May 28	15.5	6.9
29	15.0	8.9
30	15.0	7.1
31	14.8	6.4
June 1	16.5	6.2
2	16.0	7.2
3	16.1	7.5
4	17.2	6.8
5	17.5	7.8
6	17.9	7.8
7	16.3	7.9
8	16.6	8.5
9	17.4	7.1
10	15.2	8.5
11	11.1	7.0
12	11.0	6.6
13	10.0	6.5
14	10.0	2.2
15	15.1	4.8
16	14.0	8.7
17	14.0	6.0
18	10.0	6.0
19	16.7	7.1
20	18.5	9.5
21	18.3	9.0
22	18.5	8.8
23	14.9	6.5
24	15.2	6.5
25	16.1	6.7
26	(malfunction of chart)	
July 10	21.5	10.9
11	20.2	11.8
12	20.7	11.8
13	19.8	10.6
14	20.0	9.9
15	20.4	10.1
16	19.7	11.1
17	16.5	13.0
18	18.3	12.0
19	19.2	12.2
20	19.8	11.2
21	20	11.1
22	18.5	10.9
23	20.0	11.2
24	17.9	12.0
25	20.8	11.8
26	20.3	11.4
27	20.4	11.2
28	20.3	11.2
29	19.9	13.0
30	16.6	13.9
31	19.9	13.0
Aug. 1	19.1	11.6
2	18.0	12.8
3	19.0	11.0
4	19.0	10.0
5	19.3	9.3
6	19.0	9.5
7	18.1	9.1
8	17.5	8.5
9	18.2	8.6
10	18.5	10.0
11	malfunction of chart	

Table 13. Big Creek Water Temperature Data -- Daily minimum and maximum temperatures (°C) for May 28 to Aug. 13, 1976.

Date	Max.	Min.	Date	Max.	Min.
May 28	15.5	6.9	June 18	10.0	6.0
29	15.0	8.4	19	16.1	7.1
30	15.0	7.1	20	16.8	9.5
31	14.8	6.4	21	18.1	8.0
June 1	16.3	6.2	22	16.3	8.8
2	16.0	7.2	23	14.9	8.8
3	16.1	7.0	24	15.2	8.8
4	17.2	6.8	25	16.1	6.7
5	17.8	7.8	26	(malfunction of chart)	
6	17.9	7.8			
7	16.3	7.8			
8	16.0	8.5	July 10	21.5	10.5
9	17.4	7.1	11	20.2	11.8
10	18.2	8.5	12	20.7	11.8
11	17.1	7.0	13	19.8	10.8
12	17.0	8.5	14	20.0	9.9
13	16.0	8.9	15	20.4	10.1
14	16.0	8.2	16	19.7	11.1
15	16.1	8.8	17	16.5	11.0
16	14.0	8.7	18	18.1	12.0
17	14.0	8.0	19	19.2	12.2
			20	18.2	11.2
			21	20	11.1
			22	18.8	10.0
			23	20.0	11.2
			24	17.9	12.0
			25	20.0	11.0
			26	20.2	11.4
			27	20.1	11.2
			28	20.3	11.2
			29	18.0	12.0
			30	16.6	13.0
			31	19.0	12.0
			Aug. 1	18.1	11.0
			2	18.0	12.8
			3	17.0	11.0
			4	19.0	10.0
			5	18.3	8.3
			6	19.0	9.8
			7	18.1	9.1
			8	17.5	8.5
			9	18.5	8.9
			10	18.5	10.0
			11	(malfunction of chart)	

Table 14. Summary of Fish Population Data at Big Creek Stations 1,2, & 4, July 25, 1973 by the Utah Division of Wildlife Resources.

Station	Species Present	No. Fish	Mean Length	Mean Weight	Fish per mile	Biomass lbs/acre
1 (outside exclosure)	cutthroat (9) rainbow (4) sculpin (common)	13	165.2	68.8	130	7.22
2 (within exclosure)	cutthroat (43) rainbow (3) sucker (1) crayfish (common) sculpin (abundant)	47	152.4	47.2	470	26.22
4 (outside exclosure with beaver ponds)	cutthroat (64) brook (4)	68	137.56	34.1	680	26.63